CPEC, ENERGY AND WATER

A study for integrated development of Energy and Agricultural capacity of Thar region

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Conversion Factors

Inch/Pound toSI

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	0.09290	square meter (m^2)
acre	0.00405	square kilometer (km^2)
	Volume	
cubic foot (ft^3)	0.02832	cubic meter (m^3)
acre foot (af)	1233.48	cubic meter (m^3)
million acre foot (maf)	1.23348	billion cubic meter (bcm)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

SI to Inch/Pound

Multiply	By	To obtain
Length		
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
Area		
square meter (m^2)	10.76	square foot (ft^2)
square kilometer (km^2)	247.105	acre
Volume		
cubic meter (m^3)	35.31	cubic foot (ft^3)
cubic meter (m^3)	0.000810714	acre foot (af)
billion cubic meter (bcm)	0.810713	million acre foot (maf)
Flow rate		
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)

Integrated development of Power and Water infrastructure in Thar region

Abstract

Pakistan is a water stressed country and water problems are bound to increase with population growth and climate change. Similarly, demand of energy is growing faster than population growth due to economic pressure and rapidly changing living standards.

Until 1980's country's water and power infrastructures were strongly coupled because hydel was the major power source in the country. Introduction of IPPs started a major paradigm shift by moving toward imported thermal fuel. 30 years later Pakistan has abundant energy capacity that does not match the buying power of local population and industry. As a result, export industry is losing its markets.

Country's annual trade gap soared to $37.7 billion in 2017-18. It has improved lately, but will stay around $25 Billion in 2020-21, which is better yet not sustainable without effective planning and measures.

Energy imports make roughly half of the current trade deficit. High cost of energy is responsible for rest of trade deficit by causing export stagnation. Pakistan must work on reducing Oil and gas imports, and develop low cost energy resources.

Pakistan has two promising long-term energy resources.

- Indus cascade hydel projects have a potential of some 40,000 MW, and they are mostly located along the CPEC route. This cheap energy needs high initial investment and long construction time.
- Thar coal can become a cheaper and quicker alternative, but its development is slow, partially due to **infrastructure and water problems.**

This document will focus on increasing the capacity of Thar coal by addressing the water related problems.

Introduction

Thar Desert in Sindh has large deposits of coal. Its mining and power generation has already started.
However, development of infrastructural facilities and water availability is slow.
A calculated stimulus can accelerate the capacity of thermal power generation in Thar.

This “calculated stimulus package” has two dimensions.

1. Development of Thar
2. Increasing coal extraction, and generating power from it.

Analysis of both dimensions listed above shows that major common hurdle is availability of fresh water.

87% of population in Tharparker lives under poverty line. Tharparkar was officially in a drought in 1968, 1978, 1985, 1986, 1987, 1995, 1996, 1999, 2001, 2004, 2005, 2007, 2012, 2013, 2014, 2015 and 2018

Current efforts are focused on installing hand pumps and RO plants. Thar deserves a much bigger deal to play its potential role on national level.

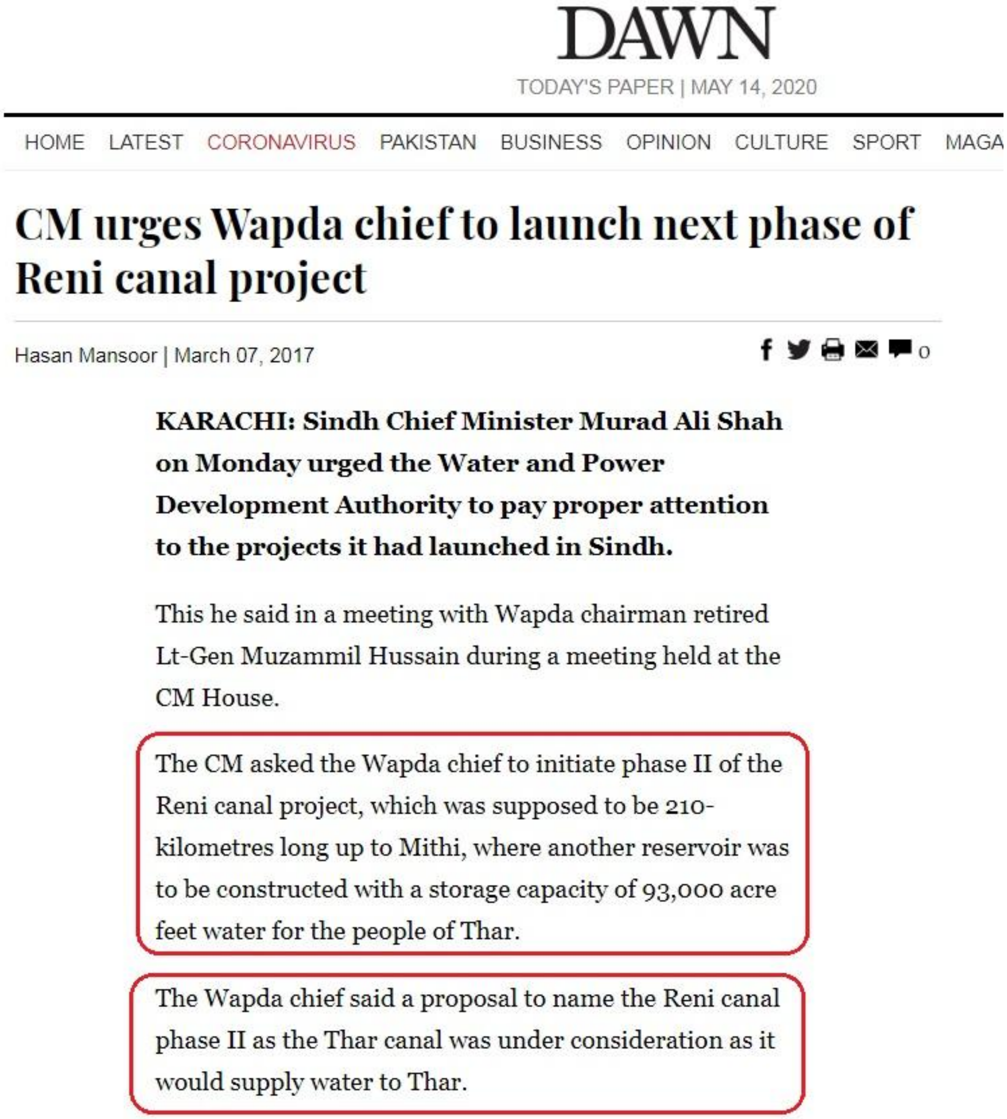
Power generation needs freshwater for steam turbines. Every 1000 MW needs 26.5 cusecs of freshwater. Which translates into 1325 cusecs (or 0.96 MAF) for 50000 MW.

Projects like Makhi Farash (Chotiari 2) are not enough to meet required pace and capacity.

There is a widely spread misconception about Rainee canal phase 2, that it will provide water to Tharparker. This is factually wrong as Rainee canal design has nothing to do with Tharparker. Its command area is within desert areas of Ghotki, Sukkur and Khairpur districts in upper Sindh

A news from March 2017 (*Link*)

Conclusion: No comments.



CM urges Wapda chief to launch next phase of Reni canal project

Hasan Mansoor | March 07, 2017

KARACHI: Sindh Chief Minister Murad Ali Shah on Monday urged the Water and Power Development Authority to pay proper attention to the projects it had launched in Sindh.

This he said in a meeting with Wapda chairman retired Lt-Gen Muzammil Hussain during a meeting held at the CM House.

The CM asked the Wapda chief to initiate phase II of the Reni canal project, which was supposed to be 210-kilometres long up to Mithi, where another reservoir was to be constructed with a storage capacity of 93,000 acre feet water for the people of Thar.

The Wapda chief said a proposal to name the Reni canal phase II as the Thar canal was under consideration as it would supply water to Thar.

Figure 1. Rainee Canal and Thar misconception.

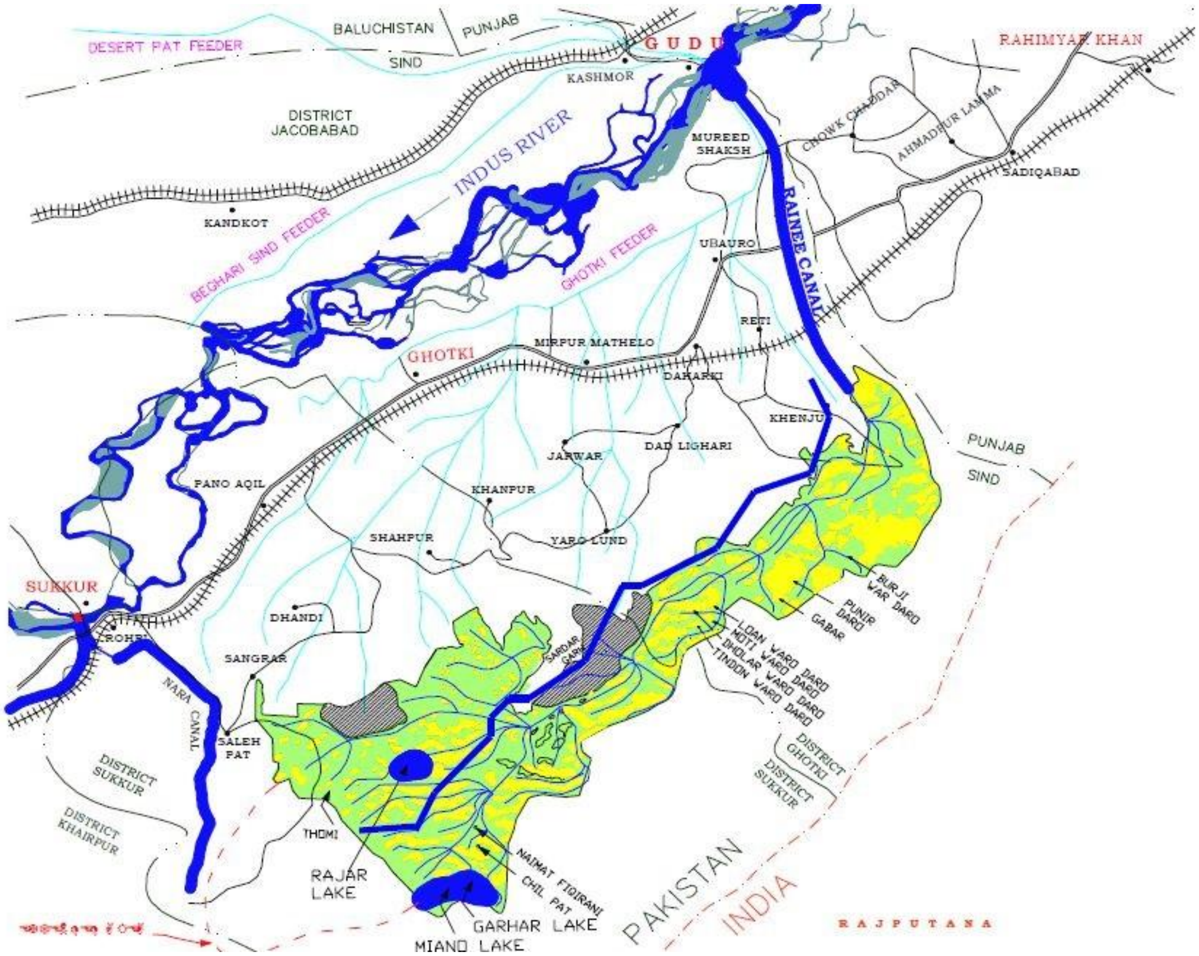


Figure 2. Rainee Canal command area is between Guddu and Sukkur Barrage

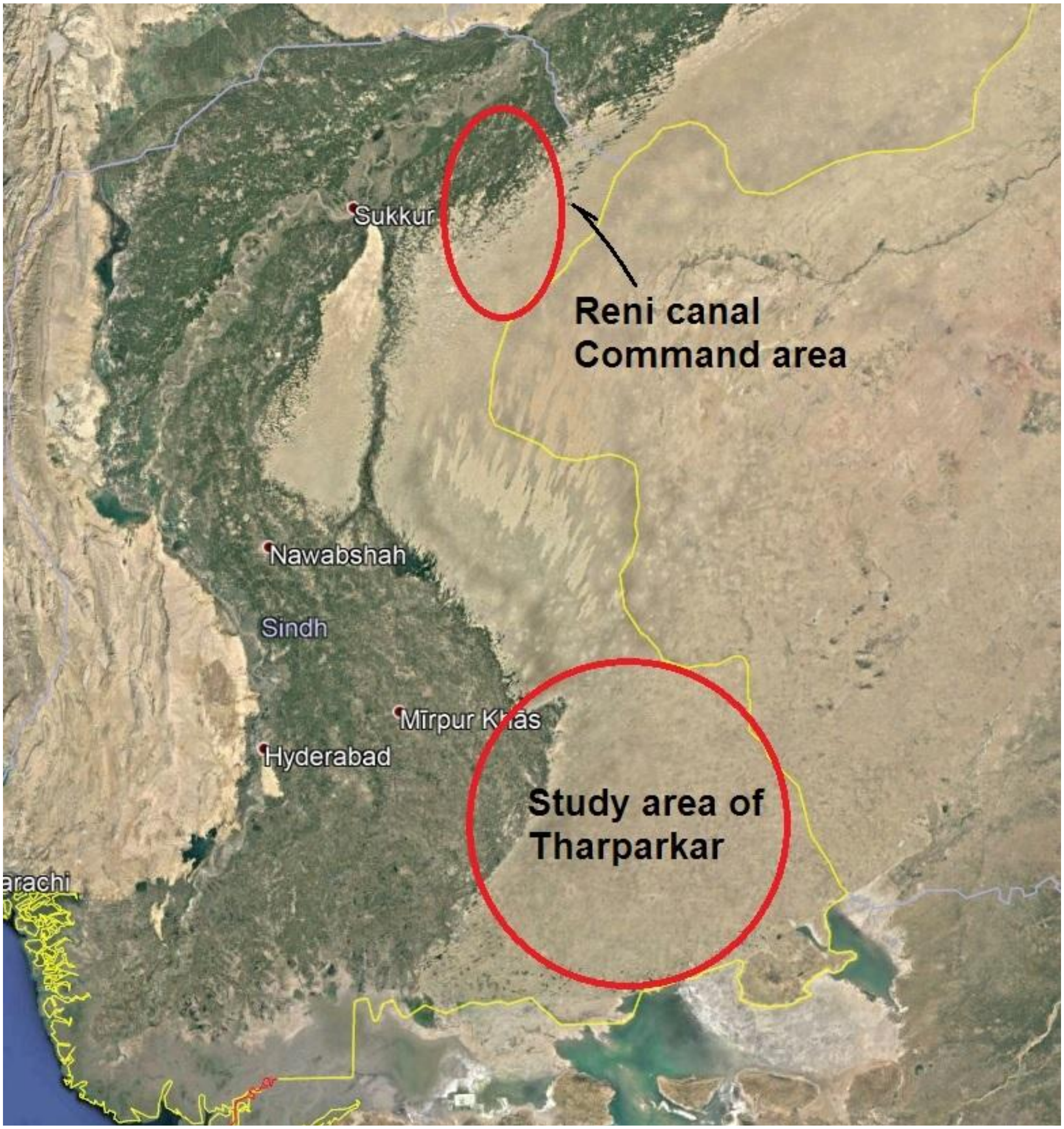


Figure 3. Rainee Canal command vs Tharparkar

How much water is needed

Power generation needs 26.5 cusecs of freshwater for every 1000 MW. (Source: Sindh Engro Coal Mining Company). 50,000 MW capacity needs 0.96 MAF water.

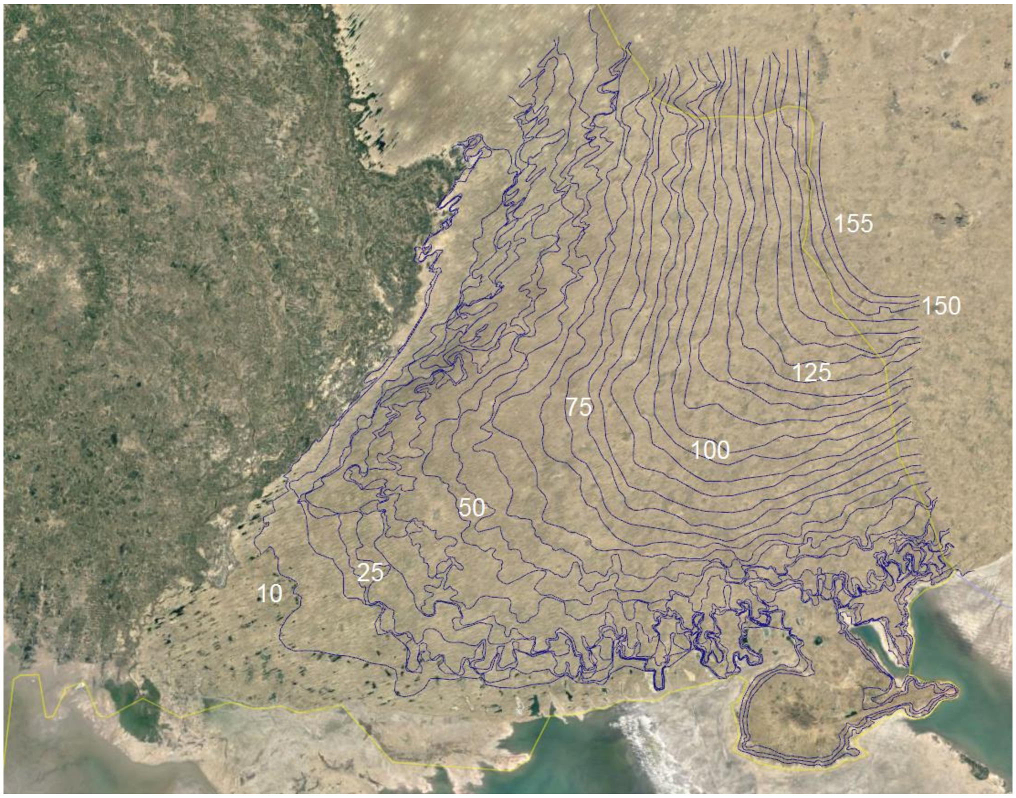


Figure 4. Thar topography defined by 98% command contours. Unit: MASL, contour interval: 5m

Area of interest for this study is southern Thar Desert located within Tharparkar and Umerkot districts.

Initially entire Thar region south of **White desert** is evaluated for irrigation network design and estimation of water requirement.

Criteria used to define the Area of interest are as following.

- Population density.
- Presence of arable land.
- Economical axis of Main Canal.
- Economical distribution of water through four spinal distributaries.
- Flexibility to adjust with long term future of Coal mining and power generation.

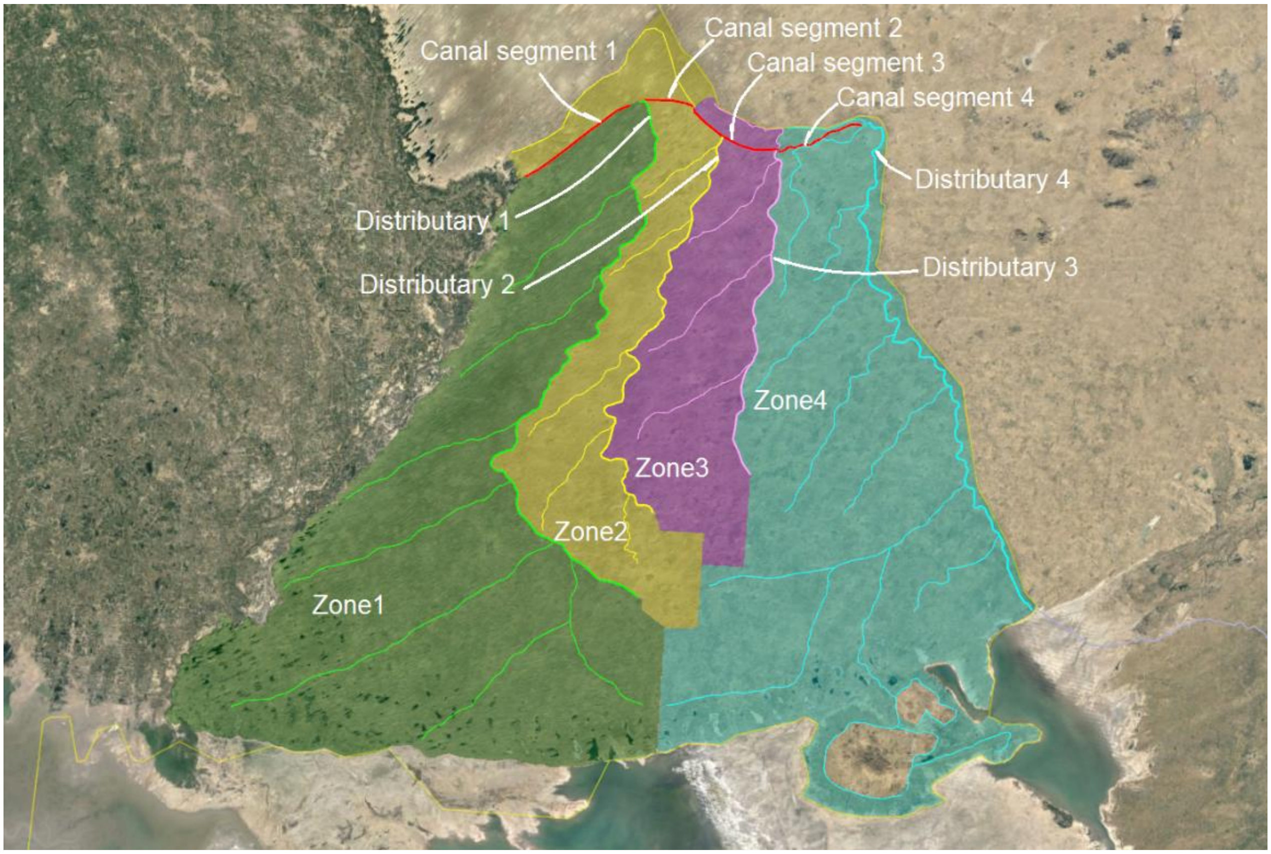


Figure 5. Possible Irrigation of Thar

Water demand and priority

Refer to Figure 5, Study area is divided into four zones. Elevation of these zones increases in Northeast direction. Zone 1 is lowest and most economical for pumping cost. Zone 4 has more population density and better and contiguous arable land areas.

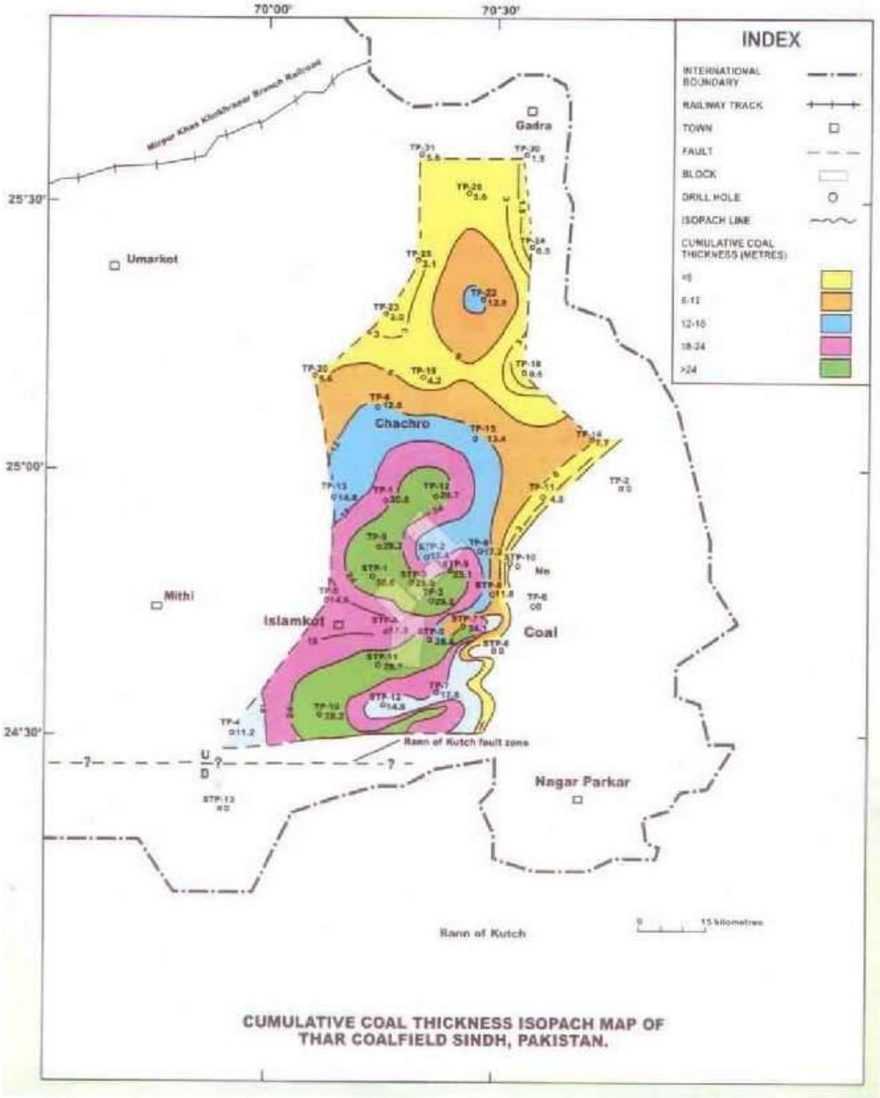


Figure 6. Coal deposits map

Coal deposits are located roughly in the middle of study area. Figure 6 is the best publicly available detailed map, but its isopatch contours show truncation on south and west side, which suggests that actual deposits do extend westwards, as far as Mithi, and Southern limit may touch International border. Zone 1 and its distributary channel is designed to avoid coal fields.

Zone 4 covers most of the eastern half including Nagarparkar. Zone 2 and 3 are comparatively smaller to provide flexibility w.r.t. long term coal mining and power generation operations in middle of the study area.

Table 1. Study area Zones

Zones	Gross Area (Million Acres)	Area %	Command regulator elevation (MASL)	Kharif allocation (MAF)	Kharif Average flow (cusecs)	Rabi Allocation (MAF)	Rabi Average flow (cusecs)
Zone 1	2.052	39.2%	45	1.235	3414	0.82	2273
Zone 2	0.711	13.6%	75	0.427	1179	0.29	788
Zone 3	0.604	11.5%	105	0.364	1106	0.24	668
Zone 4	1.867	35.7%	155	1.125	3105	0.75	2072
Total	5.234	100%		3.15	8702	2.1	5801

Main Canal

Main Canal starts near Chor and traverses a distance of 90 km to reach Gadra in north-east corner of the desert. Main canal has four segments, based upon appropriate elevation for command points of distributaries for each zone. Pumping station is needed at end of every segment to lift water to next desired elevation. Following table shows design numbers for each segment of Main Canal.

Table 2. Main Canal segments design.

Canal Segments	Length (km)	Pumping head at tail (m)	Maximum Flow Capacity (Cusecs)	Average Kharif flow (cusecs)	Average Kharif flow (cumecs)	Average Rabi flow (cusecs)	Average Rabi flow (cumecs)	Kharif average pumping (MW)	Rabi average pumping (MW)
Segment 1	30.3	46.38	10500	8702	246.4	5801	164.3	124.2	83
Segment 2	13.6	34.71	6438	5290	149.8	3528	99.9	56.6	37.8
Segment 3	23.6	35.71	4957	4111	116.4	2740	77.6	45.3	30.2
Segment 4	22.3	55.58	3745	3105	87.9	2072	58.7	53.2	35.5
Total	89.8							279.3	186.5

Table 3. Canal design details

Canal Segments	Slope	Base Width (ft)	Depth (ft)	Lining width (ft)	Channel width (m)	Flow Velocity (ft/sec)	Maximum Installed Pumping Capacity at 90% efficiency (MW)	Average Profile width for earthwork estimate (m)	Estimated Earthwork (MCM)
Segment 1	1:10K	150	11	217	64.01	5.553	150.2	85	59.7
Segment 2	1:10K	87.9	11	154.9	45.08	5.284	69.4	58	13.7
Segment 3	1:10K	66	11	133	38.40	5.12	54.6	50	21.1
Segment 4	1:10K	47.3	11	114.3	32.7	4.913	64.2	45	27.9
Total							338.4		122.4

Water availability

Water availability is the most important issue. Numerous studies of post Tarbela Kotri downstream flow, from year 2000 to 2010 show figure from 35 to 42 MAF. However, there is a decreasing trend lately, due to following reasons

1. Frequent dry periods likely related to climate change
2. Water diversion in India and Afghanistan
3. Sharp rise in number of private solar tube wells, mainly in Punjab.

In August 2019, official figure of 27.9 MAF Surplus flow at Kotri downstream was released during the announcement of Sindh barrage project. (*ref*)

Sindh barrage project aims to store 2.0 to 3.0 MAF to utilize 4.1 MAF of Kotri downstream flow.

This will spare 23.8 MAF surplus water. In absence of matching storage capacity, this surplus flow is difficult to use due to unpredictability of its amount and timing. It has to be consumed upon arrival, regardless of demand schedule.

Diamer Basha dam will provi de 6.4 MAF extra storage by 2028. Larger storage dam like **Skardu (up to 35 MAF capacity)** or **Soan (up to 38 MAF capacity)** is required for storing surplus flow. Silting of existing and new dams is a continuous and practically irreversible phenomenon. However, Soan and Skardu sites have negligible silting risk due to their respective design and location.

Large storage capacity can allow all provinces to improve quality, quantity, availability and reliability of flow for best possible productivity.

Following table shows how surplus water can be effectively utilized in accordance with 1991 accord.

Table 4. Canal design details

Province	Command	Kharif (MAF)	Rabi (MAF)	Total (MAF)
Federal Allocation	Environment/Delta	2.05	2.05	4.1
	Thar	**3.15**	**2.1**	**5.25**
	Karachi	0.4	0.4	0.8
Punjab	Thal	1.8	1.3	3.1
	Cholistan	1.35	1.1	2.45
	Surplus		1.018	1.018
Sindh	Pat feeder	0.9	0.8	1.7
	Begari	-0.67	1.4	0.73
	Rice		1.337	1.337
	Pinyari		1.3	1.3
	Phulleli		1.5	1.5
KPK		1.485	1	2.485
Balochistan		1.23	0.9	2.13
Total		11.695	16.205	27.9

Water usage practices

Pakistan uses more than 95% of its water resources for irrigation. As a result, domestic, environmental and industrial usage has suffered. Old irrigation practices and degraded irrigation network wastes too much water. Other problems like aquifer depletion and waterlogging has reduced productivity.

Operation of world's largest contiguous irrigation system with less than 10% storage capacity has its consequences. Country's major staple grain, wheat, is a Rabi crop, but there is no planning for future food security. Kharif crops are cheaply exporting water with little help to trade balance. Cropping intensity needs a strategic review for sustainable fertility of agricultural land.

In this situation, Thar can become an opportunity to adopt world's best water conservation practices for a state of art Irrigation sub-system. Use of lined canals, aqueducts, micro tunneling, Qanats, sprinklers, rain guns, drip irrigation and other tested technologies on small to large scale can become a practical model for rest of country's water economy.

Figure 7. Qanat/Karez system for water distribution is economical and attractive for desert environment .

Water conveyance from Indus

As discussed earlier, Rainee canal project is not related to Tharparkar. Makhi Farash (Chotiari-2) has scope, allocation and capacity issues. Sindh govt. has shown interest of supplying water to Thar from proposed Sindh Barrage, but its elevation, distance and location is not favorable.

A better option is to use Nara canal for conveyance of Indus water to Chor.

If needed, existing Rainee canal can transfer 3000 to 5000 cusec flow into Nara canal. Sukkur barrage can easily handle 10500 cusecs of water for Nara Canal. Current full supply discharge of Nara Canal is 16753 cusec (474.4 cumec) at 194.5 ft (59.3 m) level. Increasing it to a technically allowable level of 196.1 ft (59.8 m) will increase the flow to 28021 cusecs(793.5 cumecs). Please note that Maximum design level of Sukkur barrage is 204.5 ft (62.3 m). Current maximum allocated flow is 13861 cusec in late May, but in August 2019, Nara canal touched a peak of 16050 cusecs twice.

Nara canal uses riverbed of dried up Nara river, which has enough capacity for 500% more flow than canal's current capacity. Deepening of canal bed by **9.35** feet can increase flow capacity to 25000 cusecs while conserving the time tested flow velocity of 3.3 ft/sec. slope will decrease to

1/28328 (from existing 1/13000)

Other options include widening, straightening or raising banks. Appropriate lining can be considered for sustaining higher flow velocity without size adjustment, while avoiding seepage losses. Bed deepening in first half, banks raising in second half and lining near bridges is an optimal choice.

Chotiari reservoir with live capacity of 0.67 MAF can be used to ease demand spikes. Nara canal should have bigger spillway link to LBOD (DPOD & KPOD) to use natural Nara route for desilting and emergency spills. Proposed Sehwan barrage could have helped in easing Sukkur withdrawals by dividing its command area into half, but Sindh barrage (above Indus delta) will likely replace it.

Other largest Sukkur left bank canal is Rohri canal, with a peak allocated flow of 16965 cusec in early July. Linking Rohri Canal with Jamrao Canal (a branch of Nara Canal) can provide additional flexibility.

Cost of Thar irrigation

Energy and pumping capacity calculations are listed in Table 2 and Table 3. For all zones together, Maximum pumping capacity requirement is 338.4 MW. Average power need for Kharif is 279.3 MW and average power need for Rabi is 186.5 MW. For only lower half of Thar, power consumption will be about 33% of above figures.

In context of Thar, one 330 MW power unit of Sindh Engro Coal Mining Company can power the water supply for whole Thar and 150 more plants like itself. Earthwork volume of Thar feeder canal is roughly equal to the open pit mine of Thar block 2, but it will cost far less due 75% to 90% lesser depth of canal as compared to the mine.

Figure 8. One 330 MW plant can do the job.

Planning ahead

Depending upon the pace and methods of coal mining, land cover and topography of central Thar is bound to change. Irrigation network must be designed to coordinate with long term mining plans. Smart use of water can make a positive impact

Reservoirs, pastures, wildlife sanctuaries, plantations, highway networks and urban growth need good planning with respect to coal power infrastructural growth.

Thar watercourses can be covered with solar panels to save water while producing energy.

Local farmer rights must be conserved. Cooperative farming practices can be used for productivity boost.Water efficient farming must be encouraged. Common agricultural machinery, farm leveling equipment, drip irrigation, sprinkler and rain guns should be subsidized.

Thar has ideal conditions for growth of livestock breeding and farming. Storage, processing, packaging, transportation businesses will naturally attract investment from rest of country. Fair business environment can help Thar region to come out of poverty circle.

Dry port, rail and highway can integrate Thar with CPEC for national and international trade.

Conclusion

Allocating 1% to 3% of Indus water for Thar can change Thar into energy and agriculture hub. People lives will improve and country can get affordable 50000 to 100000 MW power. Agriculture in Thar will absorb more carbon than the coal power emissions.

Acknowledgements

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